1.2.1 Encoding a picture and a sound: the file header, the drawing list, and sampling

Name: ____________ Class: __________ Date: ___________ **Total: 30 marks**

KEY WORDS bitmap 位图 • pixel 像素 • sampling 采样 • sampling rate 采样率 • colour depth 颜色深度

Objective

Sheet 1.2 does the **arithmetic** of multimedia – the file-size formulas for a bitmap and for a sound clip. This sheet does the half the parent leaves out, and the half the written paper asks in words: **how** a bitmapped image, a vector graphic and a sound are actually **encoded**, and the exact vocabulary the mark scheme uses for each. This sheet covers syllabus 1.2.

You must be able to:

- show understanding of how data for a **bitmapped image** are encoded, using the terms **pixel**, **file header**, **image resolution**, **screen resolution** and **colour depth / bit depth**
- perform calculations to estimate the file size for a bitmap image
- show understanding of the effects of changing elements of a bitmap image on image quality and file size
- show understanding of how data for a **vector graphic** are encoded, using the terms **drawing object**, **property** and **drawing list**
- justify the use of a bitmap image or a vector graphic for a given task
- show understanding of how sound is represented and encoded, using the terms **sampling**, **sampling rate**, **sampling resolution**, **analogue** and **digital data**
- show understanding of the impact of changing the sampling rate and resolution, including the impact on file size and accuracy

1 Worked examples

Study these first. Each one shows a **method** that a question later on this sheet needs.

A bitmap is a header followed by pixels

A **bitmapped image** is stored as a grid of **pixels** – "picture elements", the smallest addressable dot – each holding one binary colour value. But the pixels alone are meaningless: a file of 786 432 numbers could be 1024 rows of 768 or 768 rows of 1024. So every bitmap file begins with a **file header**.

the file header holds	the pixel data holds
the file format, the width and height in pixels, the **colour depth**, and often a colour palette	one binary value per pixel, row by row

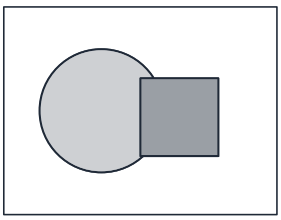
The five terms, and the differences students lose marks on:

- **Pixel** – one dot of the image, the smallest element that can be given its own colour.
- **Colour depth** (**bit depth**) – the number of **bits used to store one pixel**. n bits give 2^n different colours: 1 bit gives 2, 8 bits give 256, 24 bits give over 16 million.
- **Image resolution** – the number of pixels **in the image**, e.g. 1920×1080.
- **Screen resolution** – the number of pixels **the display has**. △ These two are different things, and the mark scheme separates them: an image of higher resolution than the screen cannot be shown at full detail, and the same image looks smaller on a higher-resolution screen.
- **File size** = image resolution × colour depth (+ the header), and the header is small enough that "estimate" means you may leave it out – but say that you have.

What changes what. Increasing the **image resolution** stores more pixels, so more detail and a proportionally larger file. Increasing the **colour depth** stores more bits per pixel, so smoother colour gradients and a proportionally larger file. Reducing either loses information **permanently** – the discarded detail cannot be recovered by enlarging the image again.

A vector is a list of instructions

what you see



Drawing list	*the whole file: the objects, in the order they are drawn*
1 Circle	centre (150, 160) radius 95 fill light line black, 1pt
2 Rectangle	corner (210, 90) width 120 height 120 fill mid
*a **drawing object***	*its **properties** – everything needed to redraw it at any size*

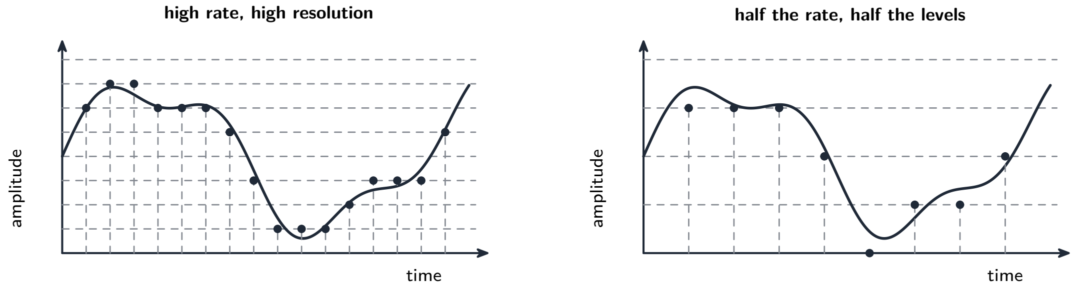
A vector graphic stores *instructions*, not pixels. Enlarging it re-runs those instructions at the new size, so the edges stay sharp and the file size does not change – which is why a logo is a vector and a photograph is not: no drawing list could describe every leaf on a tree.

- A **drawing object** is one shape in the picture: a circle, a rectangle, a line, a piece of text.

- Its **properties** are the values needed to draw it – position, size, fill colour, line colour and thickness. A circle's properties are its centre and radius; a rectangle's are a corner, a width and a height.
- The **drawing list** is the whole file: every drawing object with its properties, **in the order they are drawn** – which is what decides which shape appears on top.

Justifying one over the other. A **vector** when the picture is made of shapes and must scale: logos, diagrams, maps, fonts. Its file size depends on the **number of objects**, not on the size it is displayed at, and enlarging it re-runs the instructions so edges stay sharp. A **bitmap** when the picture is made of continuously varying colour: photographs, scans. No realistic drawing list could describe a photograph – and enlarging a bitmap only makes each stored pixel bigger, which is what "blocky" or "pixelated" means.

■ Sound is made digital by sampling



sampling rate is how often a measurement is taken – the *horizontal* spacing, in hertz

sampling resolution is how many bits each measurement gets – the number of *vertical* levels it may be snapped to

> Sound is **analogue**: it varies smoothly and without limit. Sampling makes it **digital** by measuring the amplitude at fixed instants and rounding each measurement to the nearest level a whole number of bits can hold. Raising *either* the rate or the resolution follows the wave more closely – and makes the file larger in exact proportion.

- **Analogue data** varies **continuously** and can take any value; **digital data** is stored as a fixed set of discrete binary values. A sound wave arriving at a microphone is analogue; the file is digital.
- **Sampling** is measuring the **amplitude** of the wave at regular intervals and recording each measurement as a binary number.
- **Sampling rate** – how many samples are taken **per second**, measured in **hertz**.
- **Sampling resolution** – the number of **bits used for each sample**, which fixes how many different amplitude levels a measurement can be rounded to.
- Raising **either** makes the stored version follow the original wave more closely, so the playback is more accurate – and makes the file **proportionally larger**. Halving either halves the file and loses accuracy.

△ Do not write "sampling rate is how accurate it is". Rate and resolution improve accuracy in **different ways**: rate captures more of the changes **over time**, resolution captures each measurement **more precisely**.

2 Practice

Now use the methods above.

2.1 State **three** items of data stored in the **file header** of a bitmapped image. [3]

2.2 Explain the difference between **image resolution** and **screen resolution**. [2]

2.3 A vector graphic contains one circle. State what is meant by a **drawing object** and by a **property**, using this circle as your example. [3]

2.4 Explain the difference between **analogue** and **digital** data, using sound as your example. [2]

2.5 State what is meant by the **sampling resolution** of a sound recording. [2]

3 Exam-style questions

3.1 Which term describes the number of bits used to store each measurement of a sound wave? [1]

A	B
C	D

A sampling rate
B sampling resolution
C colour depth
D image resolution

3.2 A designer creates a company logo as a **vector graphic**. It consists of a circle with a square drawn on top of it.

(a) State what is meant by a **drawing list**. [2]

(b) State the two drawing objects in this logo, and give **two** properties that would be stored for the circle. [3]

(c) The logo is enlarged to fill a billboard. Explain why it stays sharp, whereas a bitmap of the same logo would not. [2]

3.3 A phone app records voice memos.

(a) Explain how the analogue sound arriving at the microphone is turned into digital data. [3]

(b) State what is meant by the **sampling rate**, and give the unit in which it is measured. [2]

(c) The app offers a *voice* setting (8 000 Hz, 8-bit) and a *music* setting (44 100 Hz, 16-bit). Explain the effect on the **accuracy** of the recording and on the **file size** of choosing *music* instead of *voice*. [3]

(d) The developers consider raising the *music* sampling rate far above 44 100 Hz. Explain why this would increase the file size without a listener noticing any improvement. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1 any **three** of:

- the file format or file type; the width of the image in pixels; the height in pixels; the **colour depth** (bits per pixel); the colour palette

2.2

- **image resolution** is the number of pixels in the **image** itself, for example 1920×1080
- **screen resolution** is the number of pixels the **display** has, so the same image looks smaller on a higher-resolution screen, and an image with more pixels than the screen cannot be shown at full detail

2.3

- a **drawing object** is one shape in the picture – here, the circle itself
- a **property** is a value stored for that object which is needed to draw it
- for a circle the properties are its **centre** and **radius**, together with its fill colour and its line colour and thickness

2.4

- **analogue** data varies **continuously** and may take any value – the pressure wave arriving at the microphone
- **digital** data is stored as a fixed set of discrete binary values – the numbers written into the sound file

2.5

- the number of **bits used to store each sample**
- which fixes how many different amplitude levels a measurement may be rounded to: n bits give 2^n levels

3.1 B

- the number of bits per sample is the **sampling resolution**
- the sampling **rate** (**A**) is samples per second; **C** and **D** are image terms

3.2

(a)

- the drawing list is the file: every **drawing object** in the picture, each with its **properties**
- stored in the order in which they are drawn, which decides which shape appears on top

(b)

- the drawing objects are a **circle** and a **square** (or rectangle)

- two properties of the circle, from: its **centre** coordinates; its **radius**; its fill colour; its line colour; its line thickness
- (a property must be a stored *value*, not "it is round")

(c)

- a vector stores **instructions**, so enlarging it redraws the circle and the square at the new size and the edges are recalculated – they stay sharp
- a bitmap stores a fixed grid of pixels, so enlarging it only makes each stored pixel bigger; no extra detail exists to show, and the image looks blocky

3.3

(a)

- the amplitude of the wave is measured at **regular intervals** – this is **sampling**
- each measurement is **rounded** to the nearest level that the available number of bits can represent
- and stored as a **binary number**; the device that does this is an analogue-to-digital converter

(b)

- the sampling rate is the number of samples taken **per second**
- measured in **hertz** (Hz)

(c)

- **accuracy**: 44 100 samples a second captures far more of the wave's changes over time than 8 000, and 16 bits allows 65 536 amplitude levels instead of 256, so each measurement is closer to the true value – the playback is noticeably more faithful
- both effects together make the recording follow the original wave much more closely
- **file size**: the rate rises by a factor of about 5.5 and the resolution by a factor of 2, so the file is about **11 times larger** for the same length of recording

(d)

- a higher sampling rate stores proportionally more samples per second, so the file grows in exact proportion
- but human hearing has an upper frequency limit, and once the rate is high enough to capture every frequency a listener can hear, the extra samples record nothing that can be heard